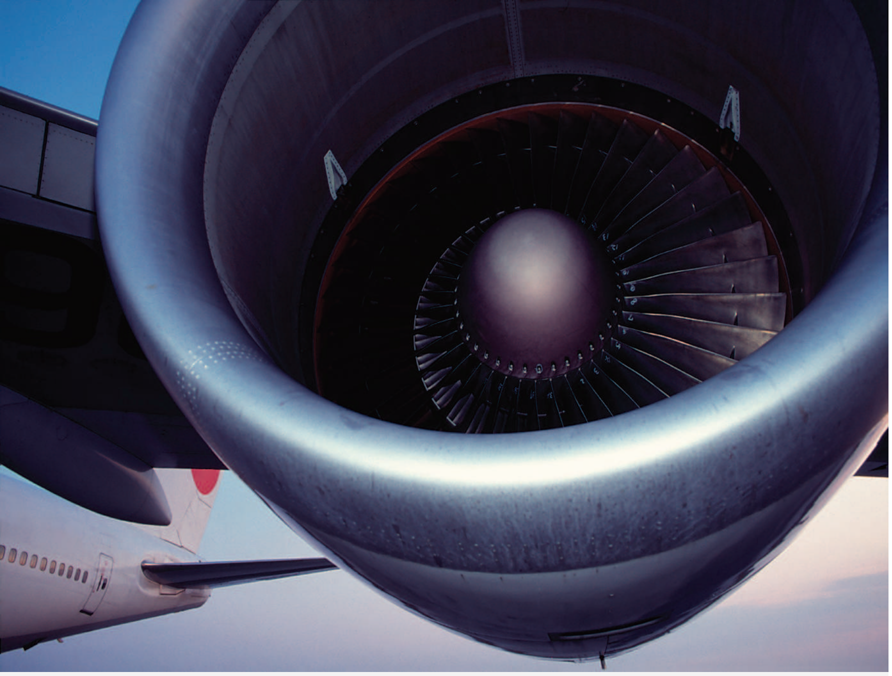

National Aeronautics and
Space Administration

Materials and Coatings

Electroactive Polymer Composites

Improving sensing and actuation devices

NASA's Langley Research Center scientists have worked on technologies that can adjust the shape of aerodynamic surfaces. As part of this research space, scientists at NASAs Langley Research Center have developed a family of electroactive polymer composites. The composites can be formed with:

-- Multilayered polyimide structures with ceramic inclusions between the layers
-- Ceramic inclusions within a polymer matrix
--Two-phase polymer composite with carbon nanotubes (CNTs) dispersed in the polymer matrix
-- Three-phase polymer composite with both CNTs and ceramic nano-inclusions
-- Multilayered, functional-gradient composite with layers of the three-phase composite
-- Intrinsic unimorph formed during film processing with single-walled CNT (SWCNT) in polyimide matrix

BENEFITS

- High strain actuation with low electric field input (order of magnitude greater than other electroactive polymers)
- Higher actuation strain energy than typical piezoceramic materials like PZT and PVDF
- No poling steps required to induce remnant polarization
- Higher temperature stability and operation
- Useful in film, fiber, nonwoven mats, and multilayer forms

technology solution

THE TECHNOLOGY

The NASA family of electroactive composites offers flexibility in the morphology of the final composite. The composites can be made of ordered, separate layers of polymer and ceramic nano-sized inclusions in the polymer matrix, or various combinations can be used to layer multifunctional gradient-type composites.

In addition, within the family, NASA has developed a novel electroactive SWCNTpolymer composite that is an intrinsic unimorph. The system demonstrates electrostrictive actuation of a composite that is caused by increased interfacial polarization at the interfaces between the nanotubes and the matrix. The technology can function as an intrinsic unimorph actuator that does not require adhesive or extraneous inactive layers to generate large bending actuation. The CNT composite forms an intrinsic unimorph actuator during the film processing, which is significant because there is no need to induce bending strain in active layers or adhesive . This makes manufacturing the actuator easy and eliminates any future delamination problems. The unimorph can actuate strains (2.6%) at low driving voltages (1) while maintaining its high performance in mechanical durability, thermal stability, and chemical resistance. The intrinsic unimorph actuator does not require adhesive or extraneous inactive layers to generate the bending actuation. The comparison of the electromechanical properties displayed in the table below conveys the significance of the NASA materials performanceNASA Langley Research Center Electroactive Polyimide (LaRC-EAP) CNT composites in a dry state without any electrolytes.

Materials	Out-of-plane strain (%)	Electric field (MVm^{-1})	Young's modulus (GPa)	Energy density ($J\ cm^{-3}$)
PVDF	0.1	50	1.6	0.0008
Irradiated PVDF-co-(trifluoroethylene)	5	150	0.4	0.5
Polyurethane	11	100	0.017	0.103
PZT	0.1	1	62	0.031
PZN-PT	1.7	12	6.9	1.0
0.05% SWCNT LaRC-EAP	2.6	0.8	3.5	1.183

The tunable multifunctionality and structural reinforcement achieved with the NASA composites could contribute to the design of intelligent and durable components for future aerospace vehicles as well as terrestrial applications.

APPLICATIONS

The technology has several potential applications:

- Actuator ion - light weight and low power that can handle harsh environments in space and on Earth
- Active control - noise control, and flow management for aircraft and industrial applications

PUBLICATIONS

Patent No: 7,402,264; 7,507,472; 7,527,751; 7,935,414

February 2009, published in Journal of Polymer Science: Part B: Polymer Physics Piezorestrictive Characteristics of Single Wall Carbon Nanotube/ Polyimide Nanocomposites at www.interscience.wiley.com

More Information

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NASA's Technology Transfer Program pursues the widest possible applications of agency technology to benefit US citizens. Through partnerships and licensing agreements with industry, the program ensures that NASA's investments in pioneering research find secondary uses that benefit the economy, create jobs, and improve quality of life.

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